Science Standards of Learning
Sample Scope & Sequence

Chemistry

Commonwealth of Virginia
Department of Education
Richmond, Virginia
2003

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Preface

As an additional resource to help school divisions develop curricula aligned to the 2003 Standards of Learning, the Virginia Department of Education has developed sample scope and sequence documents for kindergarten through grade eight and for core high school courses. These sample documents provide guidance on how the essential knowledge, skills, and processes that are identified in the Standards of Learning and the Standards of Learning Curriculum Frameworks may be introduced to students in a logical, sequential, and meaningful manner.

These sample scope and sequence documents are intended to serve as general guides to help teachers and curriculum developers align their curricula and instruction to support the Standards of Learning. Each sample document is organized around specific topics to help teachers present information in an organized, articulated manner. Also included are correlations to the Standards of Learning for that curricular area for a particular grade level or course, as well as ideas for classroom assessments and teaching resources.

The sample scope and sequence documents are not intended to prescribe how curriculum should be developed or how instruction should be delivered. Instead, they provide examples showing how teachers and school divisions might present to students in a logical and effective manner information that has been aligned with the Standards of Learning. School divisions that need assistance in developing curricula aligned with the Standards of Learning are encouraged to consider the sample scope and sequence guides. Teachers who use the documents should correlate the content identified in the guides with available instructional resources and develop lesson plans to support instruction.

The *Science Standards of Learning Sample Scope and Sequence* and the *Science Standards of Learning Curriculum Framework* can be found in both PDF and Microsoft Word file formats on the Virginia Department of Education's Web site at http://www.doe.virginia.gov/VDOE/Instruction/sol.html.

Introduction

Chemistry should be investigative and continually involve students in the scientific process. Students should be given numerous opportunities to evaluate and analyze data, particularly data they have collected. The Standards of Learning processes delineated in CH.1 are referenced numerous times in this sample scope and sequence. The classroom teacher is encouraged to incorporate them into many other parts of the curriculum as well. It is particularly important to review relevant safety procedures each time students begin laboratory experimentation.

This document is intended as a general guide to help teachers and schools frame a curriculum that incorporates the fundamentals of secondary science courses and to provide a correlation of those fundamentals to the Virginia Standards of Learning. It is organized around specific topics and includes correlations to the Science Standards of Learning, as well as ideas for assessments and resources. This document is not intended as a script for either curriculum developers or instruction, but it will provide teachers and curriculum developers a place to begin building a curriculum.

Organizing Topics	Related Standards of Learning
Introduction to Chemistry	**CH.1 a, b, c, d, e, g, h, i**
Atomic Structure	**CH.1 f, g, i; CH.2 a, b, c, i**
Properties of Matter	**CH.1 a, b, c, d, e, f, g, h; CH.2 h; CH.5 c, e, f**
Electron Configuration and the Periodic Table	**CH.1 g; CH.2 a, b, c, d, e, f, g**
Bonding, Nomenclature, and Formula Writing	**CH.1 g, h; CH.2 a, b, c, g, h; CH.3 a, b, c, d; CH.5 f**
Chemical Reactions and Equations	**CH.1 a, b, c; CH.3 d, e, f; CH.4 b, f**
Stoichiometry	**CH.1 a, f, g; CH.4 a, b**
Kinetic Theory	**CH.1 f, g, h; CH.4 c, d, e; CH.5 a-f**
Acids/Bases and Electrolytes	**CH.1 a, b, c; CH.4 g**

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Introduction to Chemistry (Scientific investigation skills and laboratory safety need to be emphasized throughout the curriculum.)	Apply experimental design used in scientific investigation: • Perform and design experiments to test predictions. • Predict outcomes when a variable is changed.	CH.1 d, e, h	Lab practical Quizzes Unit tests	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* *Safety in Science Teaching* manual *New Pathways To Chemistry* Modules #3, #5, #9, #15 Textbook SOL Test Blueprints and SOL Released Tests
	Use graphs to show the relationships of the data: • dependent variable (vertical axis) • independent variable (horizontal axis) • scale and units of graph • regression lines	CH 1 g		
	Identify and properly use the following basic lab equipment: beaker, flask, graduated cylinder, test tube, test tube rack, test tube holder, ring stand, wire gauze, clay triangle, crucible with lid, evaporation dish, watch glass, wash bottle, and dropping pipette.	CH.1 a, b, c		
	Identify, locate, and properly utilize MSDS and laboratory safety equipment including aprons, goggles, gloves, fire extinguishers, fire blanket, safety shower, eye wash, broken glass container, and fume hood.	CH.1 a, b, c		
	Express measurements in SI units-know the SI prefixes of milli-, centi-, deci-, kilo)	CH 1 g		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Introduction to Chemistry (continued)	Read instruments considering significant figures and perform mathematical operations using significant figures.	CH 1 g		
	Use appropriate technology such as graphing calculator and probeware interfaced to a graphing calculator or computer to collect and analyze data.	CH.1 g, h		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Atomic Structure	Review location, charge, and relative size of subatomic particles—electron, proton, and neutron.	CH.2 a, b, c	Lab practical Quizzes Unit tests	(See page 25 for Resource information.) *Science Standards of Learning Teacher Resource Guid*e Reference materials such as Chemical Handbooks Demonstration-size periodic table Student notebook-size periodic table Textbook SOL Test Blueprints and SOL Released Tests
	Examine the Periodic Table in regard to the following: • The atomic number of an element is the same as the number of protons. • In a neutral atom, the number of electrons is the same as the number of protons. • The average mass for each element is the weighted average of that element's naturally occurring isotopes.	CH.2 a, b, c		
	Calculate relative atomic mass.	Ch.1 f, g		
	Explain that an isotope is an atom that has a different number of neutrons than other atoms of the same element and that some isotopes are radioactive; many are not.	CH.2 b, c		
	Determine the half-life of a radioactive substance.	CH.2 b, c		
	Describe alpha, beta, and gamma radiation with respect to penetrating power, shielding, and composition.	CH.2 b, c		
	Recognize that discoveries and insights have changed the model of the atom over time.	CH.2 i		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Atomic Structure (continued)	Explain the emergence of modern theories based on historical development.	CH1 i		
	Understand and demonstrate • MSDS warnings; • safety rules for science; • laboratory safety cautions; • safe techniques and procedures.	CH.1 a, b, c		
	Relate the following major insights regarding the atomic model to the principal scientists listed below: • particles – Democritus • first atomic theory of matter – John Dalton • discovery of the electron – J. J. Thomson • discovery of the nucleus – Rutherford • discovery of charge of electron – Millikan • planetary model of atom – Neils Bohr • periodic table – Mendeleev, Moseley • quantum of energy – Planck • uncertainty principle – Heisenberg • wave theory – de Broglie	CH.1 i CH.2 i		
	Identify the modern atomic theory as the Quantum Mechanical Model.	CH.2 i		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Properties of Matter	Matter is classified by its chemical and physical properties.	CH 2 h	Lab practical Quizzes Unit tests	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Reference materials such as Chemical Handbooks Probes with calculators or computers *Safety in Science Teaching* manual Textbook SOL Test Blueprints and SOL Released Tests
	Differentiate between physical and chemical properties using common examples.	CH.2 h		
	Observe and classify matter as elements, compounds, heterogeneous mixtures, or homogeneous mixtures (solutions).	CH.2 h		
	Recognize the following physical properties: density, conductivity, melting point, boiling point, malleability, ductility, and specific heat capacity.	CH.2 h		
	Use probeware to gather data.	CH.1 a, h		
	Collect volume, mass, and temperature measurements using appropriate equipment.	CH.1 a, h		
	Understand and demonstrate • MSDS warnings; • safety rules for science; • laboratory safety cautions; • safe techniques and procedures.	CH.1 a, b, c		
	Demonstrate the following basic lab techniques: filtering, decanting, using chromatography, lighting a gas burner.	CH 1 a, b, e		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Properties of Matter (continued)	Interpret a heating curve graph.	CH.5 c CH.1 f, g		
	Calculate energy change and specific heat.	CH.5 e CH.1 f, g		
	Understand that the solid, liquid, and gas phases of a substance have different energy content.	CH.5 e		
	Review location and use of safety equipment.	CH.1 b, c		
	Demonstrate precision in measurement.	CH.1 e		
	Understand accuracy in terms of closeness to the true value of a measure.	CH.1 e, f		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Electron Configuration and the Periodic Table	For any neutral atom of a particular element, use the periodic table to determine atomic number, atomic mass, the number of protons, the number of electrons, and the number of neutrons.	CH.2 a, b, c, f	Quizzes Unit tests Student lab reports	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Periodic table Orbital models Textbook SOL Test Blueprints and SOL Released Tests
	Point out that • the Periodic Law states that when elements are arranged in order of increasing atomic number, their physical and chemical properties show a periodic pattern, which is periodicity; • the periodic table is arranged by increasing atomic numbers; • periods and groups are named by numbering column and rows.	CH.2 d, e, h		
	Understand that • electron configuration is the arrangement of electrons around the nucleus of an atom based on their energy level; • atoms can gain or lose electrons within the outer energy level.	CH.2 d, e, g		
	Use an element's electron configuration to determine the number of valence electrons and possible oxidation numbers.	CH.2 d, e, g		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Electron Configuration and the Periodic Table (continued)	Apply the following principles of electron configuration: • Aufbau Principle • Pauli Exclusion Principle • Hund's Rule • Energy levels are designated 1–7. Orbitals are designated s, p, d, and f according to their shapes. These orbitals relate to regions of the Periodic Table. • Loss of electrons from neutral atoms results in the formation of an ion with a positive charge (cation). • Gain of electrons by a neutral atom results in the formation of an ion with a negative charge (anion).	CH.2 g		
	Identify the location of the following on the periodic table: alkali metals, alkaline earth metals, transition metals, halogens, noble gases, and metalloids.	CH.2 d, e		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Electron Configuration and the Periodic Table (continued)	Determine that • vertical columns called groups have similar properties because of similar valence electron configurations; • horizontal rows called periods have somewhat predictable properties based on an increasing number of outer orbital electrons.	CH.2 d, e, f		
	Graph data to determine relationships and trends.	CH.1 g		
	Identify the following trends in the periodic table: • Shielding effect is constant across the period and increases within given groups from top to bottom. • Atomic radius decreases from left to right and increases from top to bottom within given groups. • Ionization energies generally increase from left to right and decrease from top to bottom of a given group. • Electronegativity increases from left to right, and decreases from top to bottom.	CH.2 f		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Bonding, Nomenclature, and Formula Writing	Recognize that bonds form to achieve stability.	CH.3 d	Quizzes Unit tests Student lab reports	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework.* Classroom-size periodic table Student notebook-size periodic table Models of molecular shapes Textbook SOL Test Blueprints and SOL Released Tests
	Explain the Law of Multiple Proportions and the Law of Definite Composition.	CH.2 h		
	Differentiate between empirical, molecular, and structural formulas.	CH 3 c		
	Identify and use • chemical formulas; • coefficients, chemical symbols, and subscripts.	CH.3 d		
	Illustrate how negative and positive ions are formed and how to represent them.	CH.2 a, b, c, g		
	Summarize the following concepts about ionic bonding: • Ionic bonds involve the transfer of electrons. • Ionization energy is the amount of energy needed to remove an electron from an atom in the gas phase. • Elements with low ionization energy form ions easily.	CH.3 d		
	Recognize that transition metals can have multiple oxidation states.	CH.2 g		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Bonding, Nomenclature, and Formula Writing (continued)	Summarize the following concepts about covalent bonding: • Covalent bonds involve sharing of electrons. • Polar molecules result when a molecule behaves as if one end were positive and the other negative. • Electronegativity is the measure of attraction of an atom for electrons in a covalent bond.	CH.3 d		
	Name and write formulas for certain elements that naturally occur as diatomic molecules, including oxygen, hydrogen, and nitrogen.	CH.2 a CH.3 c		
	Name binary and ionic compounds, using the roman numeral system where appropriate.	CH.3 a		
	Name compounds, using the IUPAC system.	CH 3 a		
	Recognize the formulas and names of certain polyatomic ions: carbonate, sulfate, nitrate, hydroxide, phosphate, and ammonium.	CH 3 a		
	Know chemical formulas for certain common substances including water, carbon monoxide, carbon dioxide, sulfur dioxide, and carbon tetrafluroide.	CH.3 a		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Bonding, Nomenclature, and Formula Writing (continued)	Draw Lewis Dot Diagrams to show covalent bonding.	CH.3 c		
	Predict, draw, and name molecular shapes (linear, bent, trigonal planar, tetrahedral, and trigonal pyramidal).	CH.3 a, b, c		
	Recognize polar and non-polar molecules.	CH.5 g		
	Calculate percent composition.	CH.1 g		
	Understand and demonstrate • MSDS warnings; • safety rules for science; • laboratory safety cautions; • safe techniques and procedures.	CH.1 a, b, c		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Chemical Reactions and Equations	Recognize that reactivity is the tendency of an element to enter into a chemical reaction.	CH 2 h	Quizzes Unit tests Student lab reports	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Probeware Simulation software Graphing calculators Periodic table *New Pathways to Chemistry* Module #14 *Experiment with Enzymes* Textbook SOL Test Blueprints and SOL Released Tests
	Understand that elements and compounds react in different ways	CH 3 e		
	Infer that the conservation of matter is represented by balanced equations.	CH.3 d		
	Recognize and write equations for the major types of chemical reactions--synthesis, decomposition, single replacement, double replacement, and redox reactions.	CH.3 b, e		
	Evaluate a chemical reaction and write equations, determine formulas, and balance chemical equations using coefficients.	CH.3 b, c, e		
	Understand the concept of limiting reactants in a reaction.	CH.4 b		
	Identify the following relative to chemical reactions: • Spontaneous reactions may be fast or slow. • Randomness (entropy), heat content (enthalpy), and temperature affect spontaneity.	CH.3 e, f, g CH.4 f		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Chemical Reactions and Equations (continued)	(continued) • Chemical reactions based on the net heat energy are exothermic (heat producing) and endothermic (heat absorbing). • Reaction rates/kinetics are affected by activation energy, catalysis, and the degree of randomness (entropy). • Catalysts decrease the amount of activation energy needed. • Reactions can occur in two directions simultaneously. • LeChatelier's Principle indicates the qualitative prediction of direction of change with temperature, pressure, and concentration. • A reaction is said to reach equilibrium when the forward reaction rate equals the reverse reaction rate.	CH.3 e, f, g CH.4 f		
	Interpret reaction rate diagrams.	CH 3 f		
	Identify the limiting reactant in a reaction.	CH.4 b		
	Calculate percent yield of a reaction.	CH.4 b		
	Understand and demonstrate • MSDS warnings; • safety rules for science; • laboratory safety cautions; • safe techniques and procedures.	CH.1 a, b, c		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Stoichiometry	Summarize the basic concepts of stoichiometry: • Atoms and molecules are too small to count by usual means. • A mole is a way of counting any type of particle (atoms, molecules, formula units). • Stoichiometry involves quantitative relationships. • Stoichiometric relationships are based on mole quantities in a balanced equation.	CH.4 a, b	Quizzes Unit tests Problem sets Lab practical	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Graphing calculators Electronic balances Periodic Table Textbook SOL Test Blueprints and SOL Released Tests
	Know and use • Avogadro's number; • molar volume; • molar mass; • total grams of reactant(s) = total grams of product(s); • equal volumes of gases at the same temperature and pressure have the same number of particles.	CH.4 a, b		
	Make calculations involving the following relationships: • mole-mole • mass-mass • mole-mass • mass-volume • mole-volume • volume-volume	CH.4 a, b		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Stoichiometry (continued)	Illustrate that • scientific notation is used to write very small and very large numbers; • ratios and proportions are used in calculations; • the last digit of any valid measurement must be estimated and is therefore uncertain; • dimensional Analysis is a way of translating a measurement from one unit to another unit.	CH.1 f, g		
	Make the following measurements, using the specified equipment: • volume: graduated cylinder, and pipette • mass: electronic balance • pressure: barometer/ pressure probe • temperature: thermometer/temperature probe	CH.1 a		
	Identify the limiting reactant in a chemical reaction.	CH.4 b		
	Calculate percent yield of a reaction.	CH.4 b		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Kinetic Theory	Recognize the following relative to the Kinetic Molecular Theory: • Atoms and molecules are in constant motion. • The theory is a model for predicting and explaining gas behavior. • Forces of attraction between molecules determine the physical changes of state. • Pressure, temperature, and volume changes can cause a change in physical state. • Solid, liquid, and gas phases of a substance have different energy content.	CH.5 a, b, c, d	Lab practical Quizzes Unit tests	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Graphing calculators Laser discs Textbook SOL Test Blueprints and SOL Released Tests
	Recognize the following properties of gases: • Gases have mass and occupy space, and relatively large distances separate gas particles from each other. • Gas particles are in constant, rapid, random motion and exert pressure as they collide with the walls of their containers. • An Ideal Gas does not exist, but this concept is used to model gas behavior. • A Real Gas exists, has intermolecular forces and particle volume, and can change states. • Gas molecules with the lightest mass travel fastest.	CH.4 c, d		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Kinetic Theory (continued)	State the following: • Boyle's Law • Dalton's Law of Partial Pressures • Charles' Law • the Ideal Gas Law (PV=nRT)	CH.4 c, d		
	Solve problems and interpret graphs involving all gas laws.	CH.4 c, d		
	Use pressure units such as kPa and mm of Hg.	CH.4 c, d		
	Identify the forces of attraction as hydrogen bonding, dipole-dipole attraction, and van der Waals forces.	CH.5 a, b, c		
	Perform investigations in which polar substances dissolve ionic or polar substances; nonpolar substances dissolve nonpolar substances.	CH 5 f		
	Define vapor pressure as a property of a substance determined by intermolecular forces.	CH.5 b		
	Understand that • specific amounts of energy are absorbed or released during phase changes; • the boiling point of liquids is affected by changes in atmospheric pressure.	CH.5 c, d, e		
	Define *specific heat capacity*.	CH.5 e		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Kinetic Theory (continued)	Calculate energy changes using molar heat of fusion and molar heat of vaporization.	CH.5 d, e, f, g, h CH.1 f, g		
	Perform calorimetry calculations.			
	Calculate energy changes using specific heat capacity.			
	Interpret a phase diagram of water.			
	Graph and interpret a heating curve.			
	Review solute, solvent, and solution types and calculate solution concentration.	CH.4 e CH.5 f		
	Recognize that • the number of solute particles changes the freezing point and boiling point of a pure substance; • the freezing point and boiling point of liquids are affected by the presence of certain solutes; • polar substances dissolve ionic or polar substances; non-polar substances dissolve non-polar substances.	CH.5 c, d, e, f		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Acids/Bases and Electrolytes	Recognize that acids and bases are defined by several theories.	CH.4 g	Lab practical Quizzes Unit tests	(See page 25 for Resource information.) *Science Standards of Learning Curriculum Framework* Textbook *Safety in Science Teaching* manual *New Pathways in Chemistry* Module #11 SOL Test Blueprints and SOL Released Tests
	Explain the emergence of modern theories based on historical development.			
	State the characteristics of acids and bases based on • Arrhenius Theory; • Bronsted-Lowry Theory.	CH.4 g		
	Understand that molarity = moles/dm^3 or moles/L of solution and that [ ] refers to molar concentration.	CH 4e, g		
	Define pH and pOH.	CH.4 g		
	Understand the relationship between pH and pOH.	CH.4 g		
	Explain that strong electrolytes dissociate completely and weak electrolytes dissociate partially.	CH.4 g		
	Utilize acid-base titration and pH indicators in the laboratory.	CH.4 g		
	Recognize neutralization reactions.	CH.4 g		

Organizing Topic	Essential Knowledge and Skills	Related SOL	Sample Classroom Assessment Methods	Sample Resources
Acids/Bases and Electrolytes (continued)	Understand and demonstrate • MSDS warnings; • safety rules for science; • laboratory safety cautions; • safe techniques and procedures.	CH.1 a, b, c		

Resources

*Experiment with Enzymes**

*New Pathways to Chemistry**

Safety in Science Teaching manual – http://www.doe.virginia.gov/VDOE/Instruction/safetymanual.pdf

Science Standards of Learning Curriculum Framework – http://www.doe.virginia.gov/VDOE/Instruction/Science/sciCF.html

SOL Released Tests – http://www.doe.virginia.gov/VDOE/Assessment/releasedtests.html

SOL Test Blueprints – http://www.doe.virginia.gov/VDOE/Assessment/soltests/home.html

*Printed copies are available by contacting Eric M. Rhoades, secondary science specialist, at Eric.Rhoades@doe.virginia.gov. Other resources can be purchased from numerous vendors who sell science supplies and equipment.